The Institutional Costs of Adaptation: Agricultural Drainage in the United States

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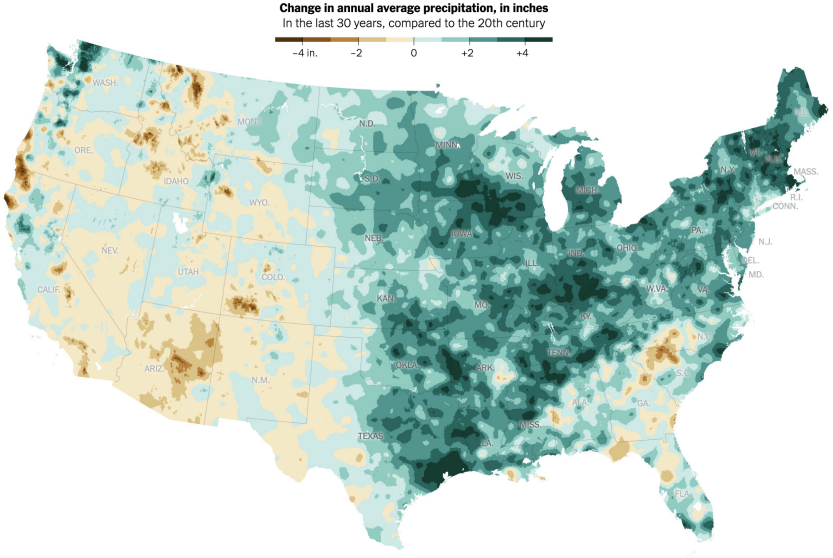
Today's *Wall Street Journal*

Wet and cool temperatures in key parts of the Midwest delayed farmers' planting plans, leaving them days to get crops in the ground before they start to lose out on a bigger harvest.

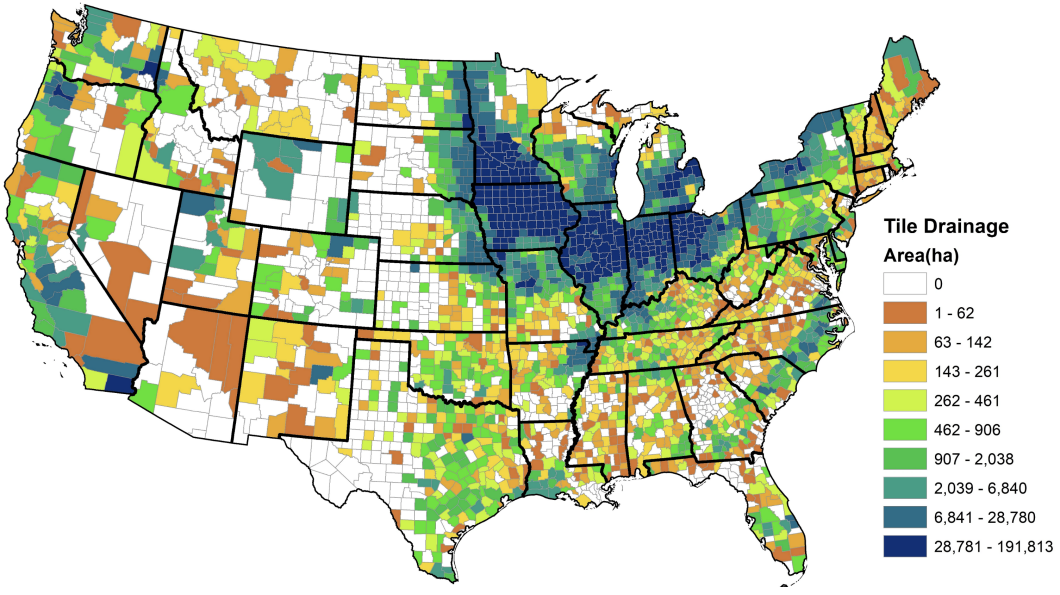
Sean Elliot, a sixth-generation farmer in Iroquois County, Ill., planted his crop until midnight on Monday and got back out to the fields at 5:30 a.m. the next day to resume planting. Some of his land is still wet, but with more rain expected this weekend, Mr. Elliot said he is racing to get as much corn and soybean planted as he can this week. He has a drainage system installed that will help dry out his soil, but his neighbors that don't will probably lose out on some of their yields, he said.

Climate Change: Wetter



Source: NOAA's National Centers for Environmental Information

Climate Change: Warmer



This Paper

- What was the impact of agricultural drainage on farmland and farmland value in the eastern U.S.?
- Construct measure of "need" for drainage using soil drainage index and use drainage law passage as treatment in a diff-in-diff framework
- Focus on institutional innovation and lessons for future adaptation

Drainage and Swamp Land Acts

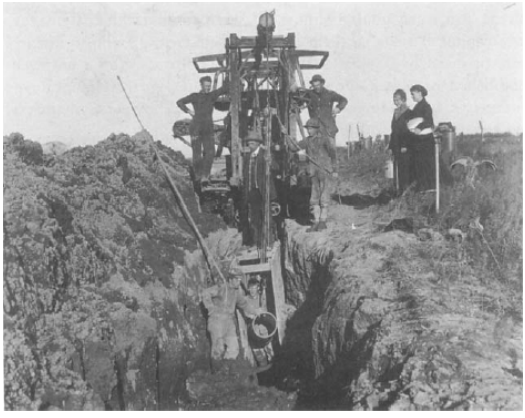
- First tile drainage in US: 1835
- A series of Swamp Land Acts turned surplus swamp lands over to states for reclamation
- Huge swaths of land granted to states ($65M$ acres by early 1910s)
- Initial efforts by state governments to drain were unsuccessful
- Some large farms experiment with drainage

Table: Swamp Allotments

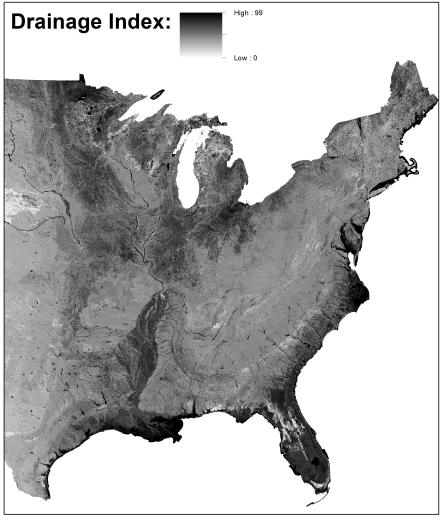
Year	State	Acres
1849	Louisiana	9,493,456
1850	Alabama	441,289
	Arkansas	7,686,575
	California	2,192,875
	Florida	20,325,013
	Illinois	1,460,184
	Indiana	1,259,231
	Iowa	1,196,392
	Michigan	5,680,310
	Mississippi	3,347,860
	Missouri	3,432,481
	Ohio	26,372
	Wisconsin	3,360,786
1860	Minnesota	4,706,503
	Oregon	286,108
TOTAL		84,895,415

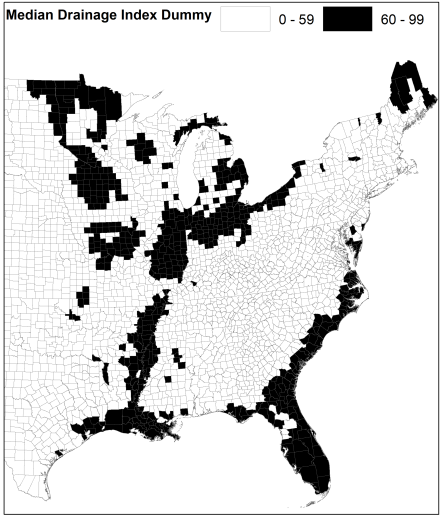
Source: Fretwell (1996)

Drainage Was a Big Deal



Drainage Index





The Drainage Coordination Problem

- Over time, common law and legislation defined rights to drain among neighboring farms
- A system of integrated outlet channels was often a prerequisite to successful drainage
- Voluntary provision is hindered by collective action issues (Olson, 1989)
- Ostrom (1990) provides guidance to the settings where local groups can successfully cooperate in managing natural resource problems:
  - Rights to organize locally recognized by the central or local government
  - Decisions nested in local organizations
- Bretsen and Hill (2006) for irrigation districts and Edwards (2016) for groundwater districts show the success of state laws empowering local management

The Drainage Coordination Problem

> *In order to secure the necessary cooperation for efficient work in all cases and to set out the detail of procedure so as to insure uniform practice, some legal method of compulsion has been found necessary, and drainage statutes have been enacted by many of the States. All the persons interested may not agree as to the necessity for the improvement, and even if they do, when it comes to deciding what lands shall be embraced in the project, where the ditches shall be located, how the work shall be done, and particularly, what each individual landowner shall pay, differences of opinion are sure to arise. To overcome this diversified sentiment and enable the owners of swamp and overflowed lands to reclaim the same in an efficient and equitable manner, drainage laws have been found necessary.*

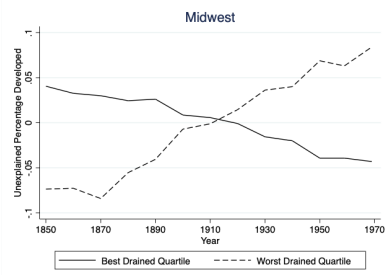
1907 report to the U.S. Senate on the status of *Swamp and Overflowed Lands in the United States* (Wright, 1907)

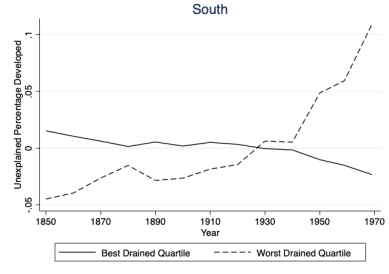
Drainage District Legislation

Table: Year of Drainage District Legislation

State	Year	State	Year
Michigan	1857	Kentucky	1912
Ohio	1859	Arkansas	1921
Iowa	1873	Louisiana	1921
Illinois	1878	Oklahoma	1921
Kansas	1879	Virginia	1924
Nebraska	1881	Georgia	1926
Minnesota	1887	Florida	1927
Indiana	1889	Missouri	1929
Wisconsin	1891	South Dakota	1929
Texas	1904	Mississippi	1930
North Dakota	1905	North Carolina	1930
South Carolina	1911	Tennessee	1932

Source: Table is adapted from McCorvie and Lant (1993) based on data from Austin (1931)





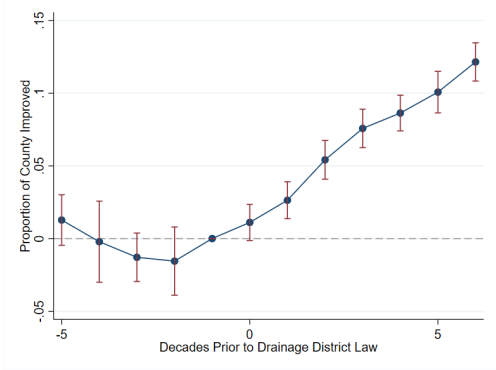
Empirical Strategy

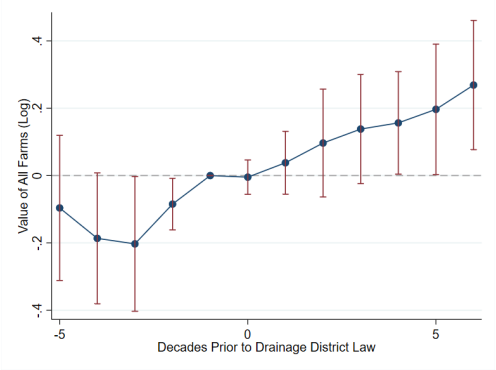
- The typical approach for recovering difference-in-difference estimates of average treatment effects (ATT) would be to use a two-way fixed effects estimator (TWFE) of the form:

$$Y_{ist} = \beta_{TWFE} PostLaw_{st} \times HighDI_i + \lambda_i + \tau_t + \varepsilon_{ist}$$

  - Y_{ist} is the outcome for county i in state s in year t
  - λ_i and τ_t are county and year FE
  - *PostLaw* d- state as passed a drainage law
  - and *HighDI* - county is designated as having a high DI, respectively.
- Identification: Comparison group is counties within a state that become treated, but which differ in their need for drainage
- de Chaisemartin and d'Haultfoeuille (2020) and Callaway and Sant'Anna (2020) both propose alternative DiD estimators that are robust to heterogeneous treatment effects across time and/or cohorts

Event Studies





Estimates of Ag Development after Drainage District Laws

	(1)	(2)	(3)	(4)	(5)	(6)
	ALL COUNTIES		MIDWEST		SOUTH	
	% Impr.	Ag Value (log)	% Impr.	Ag Value (log)	% Impr.	Ag Value (log)
			de Chaisemartin & D'Haultfoeuille (2020)			
Post Drain	0.068***	0.127*	0.091	0.243**	0.074***	0.093
	(0.005)	(0.069)	(0.007)	(0.115)	(0.025)	(0.098)
			Callaway & Sant'Anna (2020)			
Post Drain	0.157***	0.147	0.116***	0.011	0.089**	0.00
	(0.034)	(0.286)	(0.027)	(0.187)	(0.041)	(0.137)
			Two-Way Fixed Effects			
Post Drain	0.092***	0.265***	0.125***	0.530***	0.108**	0.226
	(0.019)	(0.092)	(0.031)	(0.120)	(0.031)	(0.141)
Counties	2,949	2,951	621	621	726	727
R^2 (TWFE)	0.882	0.882	0.867	0.88	0.798	0.904

Notes: Standard errors are clustered by county and reported in parentheses; statistical significance is indicated by $*(p < 0.1), **(p < 0.05), ***(p < 0.01)$.

Results Summary

- The coefficient estimates are fairly consistent and robust for improved acres
- A poorly drained county (DI>60) will see a 6.8 to 15.7 percentage point increase in the area of the county with improved agricultural land
- The full effect of drainage law passage occurs over 70 years
  - Overall farm values increases from 13.5-30.2% depending on estimator
  - Drainage increased the value of the average high-DI county by $14.4-32.3M
  - Drainage in 513 high-DI counties added $7.4-16.6B to U.S. agricultural land value
- Results are much stronger across Midwest than the South

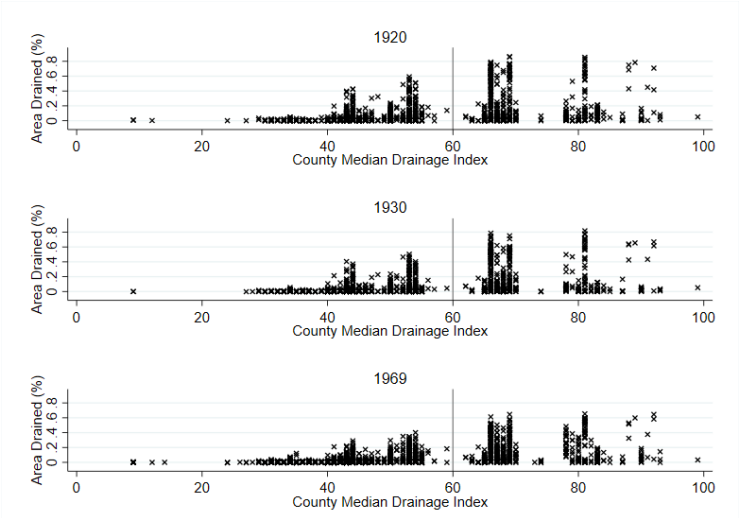
Thank you!

Conditional Summary Statistics

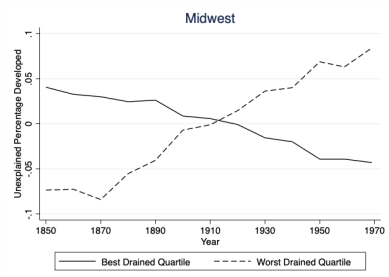
Variable	Drainage Index<60 Pre	Drainage Index<60 Post	Drainage Index >60 Pre	Drainage Index >60 Post
Total Value in Farms (2020$ millions)	132.75	283.76	106.58	433.28
	(174.79)	(260.00)	(153.04)	(408.16)
Pct. of County Improved	0.29	0.39	0.22	0.50
	(0.20)	(0.24)	(0.22)	(0.27)
Total Farms	1,669	1,777	1,380	2,003
	(1,358)	(1,096)	(1,493)	(1,259)
Total Acres in Farms	202,257	288,167	162,324	279,917
	(138,779)	(190,034)	(133,031)	(166,578)
Median Drainage Index	43.84		72.47	
	(6.24)		(7.83)	
Median Productivity Index	8.09		10.16	
	(3.93)		(3.42)	

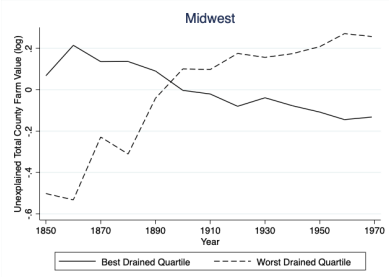
Notes: Summary statistics conditional on treatment status: high drainage counties $DI >$ 60 and pre/post drainage district laws. All values are the mean value of all the counties in that treatment status for the variable described on the left and for all years in that status. Standard deviations are reported in parentheses.

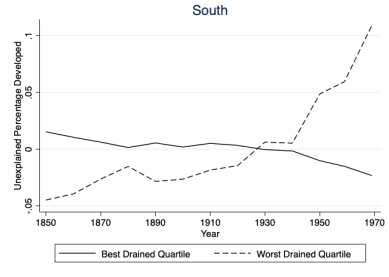
Drainage Index and Observed Drainage

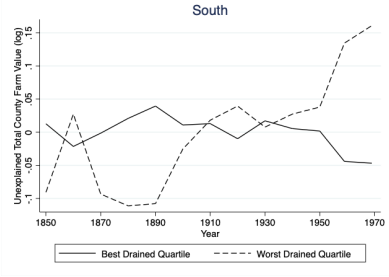


Drainage Quartile Comparisons

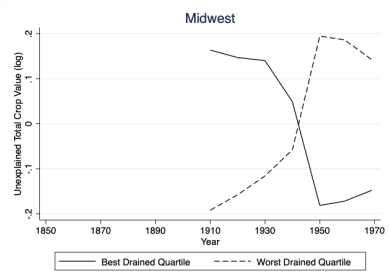


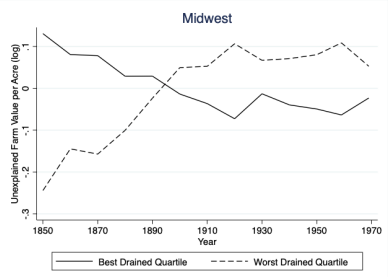


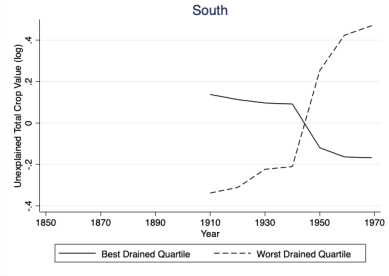


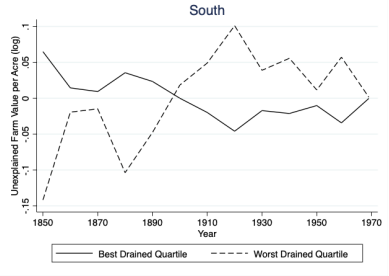


Alternative Drainage Quartile Comparisons









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